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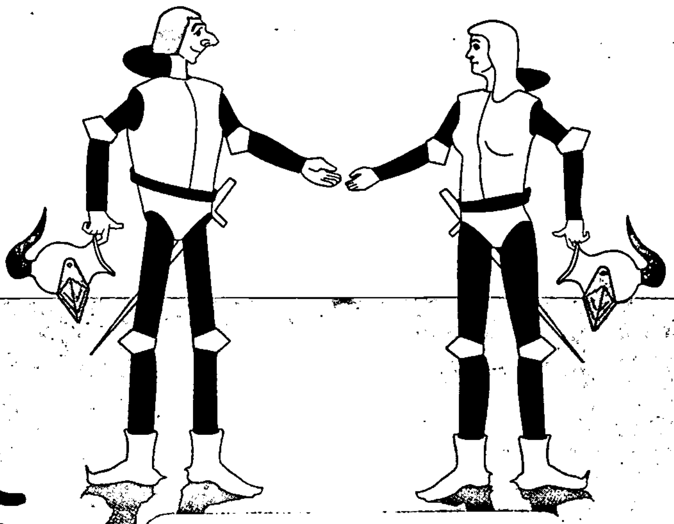
ABSTRACT

The goal of this safety guide is to enable students to take more responsibility for lab safety by using the Self-Audit System for Students and to understand the responsibility for safety shared by the institution through the development and maintenance of a Chemical Hygiene Plan. This student guide discusses safety equipment and the procedures that chemical manufacturers must use in labeling their products. A chart of hazardous materials, their characteristics, and routes of exposure is provided. A Student Hazardous Chemical Usage Sheet is provided, as well as a list of hotline numbers pertaining to a variety of safety issues. Contains 20 references. (DDR)

UNDERSTANDING CHEMICAL HAZARDS:

A Guide for Students



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Several ACS members contributed to the handbook. We are grateful for the time and effort that they took to ensure its completeness and accuracy. The primary authors of this handbook are Warren K. Kingsley (Editor, Chemical Health & Safety) and Daniel F. Liberman (Boston University). Review and helpful commentary were received from Barry Bochner (Fabricolor); Sunney I. Chan (California Institute of Technology); Laurence Doemeny, (National Institute for Occupational Safety and Health) (NIOSH)); Alan J. Hart; Vera Kolb (University of Wisconsin-Parkside); Eileen B. Segal (Associate Editor, Chemical Health & Safety); and Jennifer Silk (U.S. Occupational Safety and Health Administration). (The affiliations are listed for identification purposes only and do not represent an endorsement of the material presented). The pamphlet has benefitted from the editing and production assistance of Minh-Son T. Dang, Kathleen A. Ream, and Susan M. Turner of the ACS Department of Government Relations and Science Policy.

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DISCLAIMER

The material contained in this handbook has been compiled from sources believed to be reliable and to represent the best opinions on understanding chemical hazards. This handbook is intended to serve only as a starting point for good laboratory practices and does not purport to specify minimal legal standards or to represent the policy of the American Chemical Society. No warranty, guarantee, or representation is made by the ACS, or its members, as to the accuracy or sufficiency of the information contained herein, and the Society and its members assume no responsibility in connection therewith. Users of this manual should consult pertinent local, state, and federal laws and legal counsel prior to initiating any hazard communication program or laboratory standard program.

UNDERSTANDING CHEMICAL HAZARDS:

A GUIDE FOR STUDENTS

Prepared by the

Task Force on Occupational Health and Safety

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ACRONYM KEY

ACGIH	American Conference of Governmental Industrial Hygienists
ACS	American Chemical Society
CHP	Chemical Hygiene Plan
EPA	Environmental Protection Agency
HCS	Hazard Communication Standard
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit (OSHA)
REL	Recommended Exposure Limit (NIOSH)
SOPs	Standard Operating Procedures
TLV	Threshold Limit Value (ACGIH)

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A GUIDE FOR STUDENTS

Chemistry, the study of substances in our world, is challenging and can be exciting.

Laboratory work is an important facet of this study, for it enables you, ***the student***, to apply what you have learned. However, laboratory work often involves exposure to chemicals that are harmful if mishandled, so this guide has been prepared as an aid to you in working safely with chemicals.

STUDENT RESPONSIBILITY

The guide cites health and safety regulations that *should* be observed by the college/university and its agents (e.g., laboratory instructors), but primary responsibility for your actions and your well-being still rests with you.

Passages that follow this icon cite your responsibilities to protect yourself, others, and the environment during your lab experience.

Take the time to read the guide, then keep it handy for ready reference.

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Review the following **"Self-Audit System for Students"** before starting any experiment or handling chemicals. This list of questions serves as a starting point which you may supplement or modify. Your professor or teaching assistant will help you answer these questions. Answers should be found in the Chemical Hygiene Plan (CHP).

SELF-AUDIT SYSTEM FOR STUDENTS

✓ Do I know the locations of the emergency equipment (i.e., eyewash, safety shower, fire extinguisher, spill clean-up kits, first-aid supplies)?

✓ Do I always wear safety goggles when I work in the laboratory?

✓ Have I read and am I familiar with key elements of the standard operating procedures (SOPs) for the experiment that I am to perform?

✓ Do I understand the information in each material safety data sheet (MSDS)?

✓ Has the laboratory instructor identified key proper personal protective equipment that I need to work with the chemicals that I will use in the experiment that I am about to perform?

✓ Do the chemicals that I will be using require special environments, or designated areas as described in the experiment procedure?

✓ Have I been provided with sufficient space to work safely?

✓ Is the equipment to be used compatible with the chemicals that I will be using?

✓ Are the fume hoods working adequately?

✓ Have I been trained, and do I know how to use the protective equipment properly?

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- ✓ Have I discussed with my lab partners the protective equipment that they should wear?
- ✓ Are proper spill control materials available in the event of an accident?
- ✓ Is there an emergency plan in case the ventilation (hood) fails, or an accident occurs, and am I familiar with this plan?
- ✓ Do I know how to initiate an emergency evacuation, and do I know the emergency evacuation route?
- ✓ Do I know the potential interactions of chemicals that I will be working with, i.e., whether they could lead to a hazardous incident?

As you get into more advanced course work, or work in industry, MSDSs will be an important part of your work. They will provide you with critical information to protect yourself, others, and the environment. But you may want to know more. The following are suggested self-audit questions for the more advanced course work.

- ✓ Have I read the MSDS or other safety information for each chemical that I am about to handle?
- ✓ Have I checked reference sources in addition to the MSDS for the possibilities of unexpected reactions?
- ✓ Is the space appropriate for the materials with which I am working?

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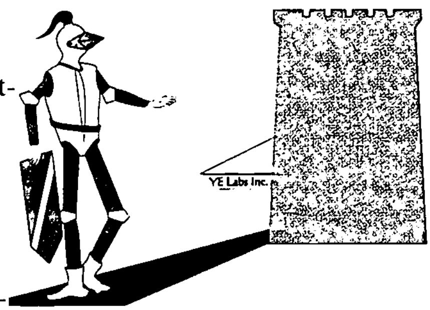
SAFETY: SHARED RESPONSIBILITIES

You and the college/university are responsible for the safety of the laboratory program. Presented below are specific areas of the program that demand your attention. Direct any questions relative to these areas to the laboratory instructor.

Chemical Hygiene Plan

For all laboratories, the college/university must develop and maintain a **Chemical Hygiene Plan** that includes standard operating procedures to ensure your safety. The SOPs contain detailed protocols and procedures for conducting experiments. In addition, the college/university must appoint a chemical hygiene officer to be responsible for implementing and enforcing the CHP.



At the beginning of the laboratory course, the laboratory instructor must inform you of the Plan, its contents, and its location, as substantiated by a sign-off form.

Know the location of the CHP and the name, office location, and telephone number of the chemical hygiene officer. Become familiar with the contents of the CHP, particularly the procedures that apply to your laboratory activities.

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Personal Protective Equipment

Your syllabus will list the appropriate personal protective equipment, (e.g., goggles, apron, laboratory coat), the cost of which may have been included in your laboratory fees, depending on your institution. The instructor must explain how to use the equipment correctly.

Make sure that your personal protective equipment functions properly, and wear it as appropriate during laboratory work.

Safe Work Practices

The college/university works very hard to maintain safe laboratories and to ensure that all laboratory equipment, including emergency equipment, is functioning properly and is checked regularly. Your instructor is available to answer your questions about the physical, chemical, hazardous, and toxic properties of the chemicals used in the laboratory work.

Follow all the safety rules established for the laboratory and the instructions set forth in the laboratory syllabus. Report any unsafe conditions or acts to the instructor immediately.

Labels

The college/university must monitor for proper labeling of all chemicals and reagents supplied for laboratory work. The instructor must explain the labeling system used at the college/university, as well as the labeling system used by the suppliers of the chemicals and reagents. The instructor is responsible for replacing damaged or missing labels.

Learn the labeling system used at the college/university. Read the labels before using chemicals and reagents. Notify the instructor of damaged or missing labels.

Material Safety Data Sheets

The laboratory must have a Material Safety Data Sheet for each **hazardous** chemical that you are to use. The instructor is familiar with these MSDSs and will make them available to you upon request.

Read each MSDS that is relevant to the experiment being conducted. You are encouraged to maintain a log of each MSDS that you read.

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RATIONALE FOR CHEMICAL HEALTH AND SAFETY

Millions of people are exposed to chemicals at work. If mishandled, many of these chemicals can cause injury. To reduce such risk, the Occupational Safety and Health Administration (OSHA), the primary federal agency overseeing workplace safety, administers regulations, such as the **Hazard Communication Standard** (HCS) and the **Occupational Exposure to Hazardous Chemicals in Laboratories** (Laboratory Standard). In addition, some states have adopted requirements that exceed those of the HCS and/or the Laboratory Standard.

OSHA regulations do not apply to you as a student in a science class. However, your college/university may be liable if you are injured. Therefore, your college/university should prepare you in the same manner as it prepares an employee in compliance with OSHA regulations. The laboratory instructor should counsel you as to any college/university regulation that is stricter than federal regulations.

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A GUIDE FOR STUDENTS

Hazard Communication Standard

Considered a worker's right-to-know regulation, the **Hazard Communication Standard** requires that employers:

- ❑ Identify and advise employees of chemical hazards in the workplace;
- ❑ Maintain proper container labeling;
- ❑ Have an MSDS readily available on site for each hazardous chemical;
- ❑ Establish training programs; and
- ❑ Prepare a written program for implementing the regulations.

Manufacturers of chemicals are required to prepare an MSDS for each hazardous chemical that they produce, but most manufacturers prepare MSDSs for all their chemicals, hazardous or not. An MSDS furnishes a detailed description of a given chemical, information as to its physical and chemical properties, its safe and proper use, and personal and environmental protection. The manufacturer provides the MSDS either prior to, or with, the first shipment of the chemical.

Laboratory Standard

The **Laboratory Standard**, designed to protect laboratory employees from overexposure to hazardous chemicals, requires:

- ❑ Monitoring of the laboratory for indications of overexposure;
- ❑ Medical consultations and examinations for workers who may have been overexposed;
- ❑ Development of a CHP, including appointment of a chemical hygiene officer;
- ❑ Designation of specific laboratory areas for work with carcinogens, mutagens, teratogens, or highly toxic substances;
- ❑ Training programs; and
- ❑ Access to reference materials, including, but not limited to, MSDSs.

UNDERSTANDING THE MSDS

Do not presume that necessary information is contained in the MSDS.

The MSDS should contain all information relevant to the hazards the chemical poses, as well as protective measures and health related matters. However, a given manufacturer may not include some information because the manufacturer feels that doing so may reveal a trade secret.

Since the quantity and quality of information contained in MSDSs varies, the laboratory instructor must be able to answer your questions or refer you to additional material if you ask.

Do not perform an experiment until you feel that you are fully informed about the chemicals of the experiment and are comfortable with the safety precautions.

A chemical will do exactly what the MSDS says: a flammable chemical will ignite; a corrosive chemical will damage living tissue.

Notes

Use the personal protective clothing and equipment prescribed for the experiment. Know how to use the proper emergency equipment.

Although the format may differ from one MSDS to another, the following information must be included.

1. ***The Chemical Product and Manufacturer Identification***. To enable you to identify fully the chemical product and to enable the college/university to inventory it, the MSDS lists:
   - ❑ The manufacturer's name, address, and telephone number;
   - ❑ Emergency telephone numbers;
   - ❑ Chemical names;
   - ❑ Trade names;
   - ❑ Chemical family and formula; and
   - ❑ For elements and compounds, the Chemical Abstracts Service number.

2. ***Data on the Product Ingredients.*** The MSDS identifies any hazardous ingredient that comprises at least 1 percent of the product and any carcinogen that comprises at least 0.1 percent. In addition, the MSDS cites exposure limits for ingredients as applicable.

   This information is required for the development of proper handling procedures and to assist medical personnel in treating persons exposed to toxic ingredients.

3. *Physical Characteristics*. The MSDS lists the melting point, boiling point, specific gravity, vapor pressure, vapor density, evaporation rate, water solubility of the product, and the percentage of the product that is volatile. The MSDS also describes the appearance and the odor of the product.

4. *Health Hazard Information*. In addition to exposure limits for each hazardous ingredient, the MSDS identifies the principal route(s) of exposure (e.g., ingestion, inhalation, absorption through the skin or eye), the symptoms of overexposure (e.g., headache, nausea), and the effects of overexposure (e.g., skin rash, dizziness).

5. *Reactive Properties and Firefighting Measures*. The MSDS identifies the flash point of the product—the temperature at which the product will emit vapors that combine with air to form an ignitable mixture. Based on the flash point, the product is ranked according to its potential as a fire hazard.

   Suitable extinguishing agents (e.g., water, dry chemical, foam) and unusual fire or explosion hazard data are listed.

   In addition, the MSDS describes the propensity of the product to react and release energy under certain conditions or when it comes into contact with certain substances. This information includes: instability and the conditions to avoid; incompatibility and materials to avoid; and hazardous decomposition byproducts.

6. *Accidental Release Response*. The MSDS prescribes the measures to be taken after an accidental release or spill.

Know the procedure to follow in the laboratory if there is an accidental release or spill.

7. *Safe Handling and Storage*. The MSDS presents correct handling and storage instructions.

Read these instructions before using or storing the product.

8. *Personal Protective Equipment*. The MSDS lists the personal protective equipment to be used with the product. Because the MSDS bases the equipment needs on a worst-case situation, the syllabus will list the equipment required for the experiments.

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LABELS

Read the label on the container as well as the MSDS for the product. ***Labels on many containers distributed prior to 1985 do not contain hazard warnings.*** The label of a shipped chemical (figure 1) includes the name of the product, the name and address of the manufacturer, and physical and health hazards. Labels on the chemicals that are distributed from the original containers should include the name of the product and physical and health hazards.

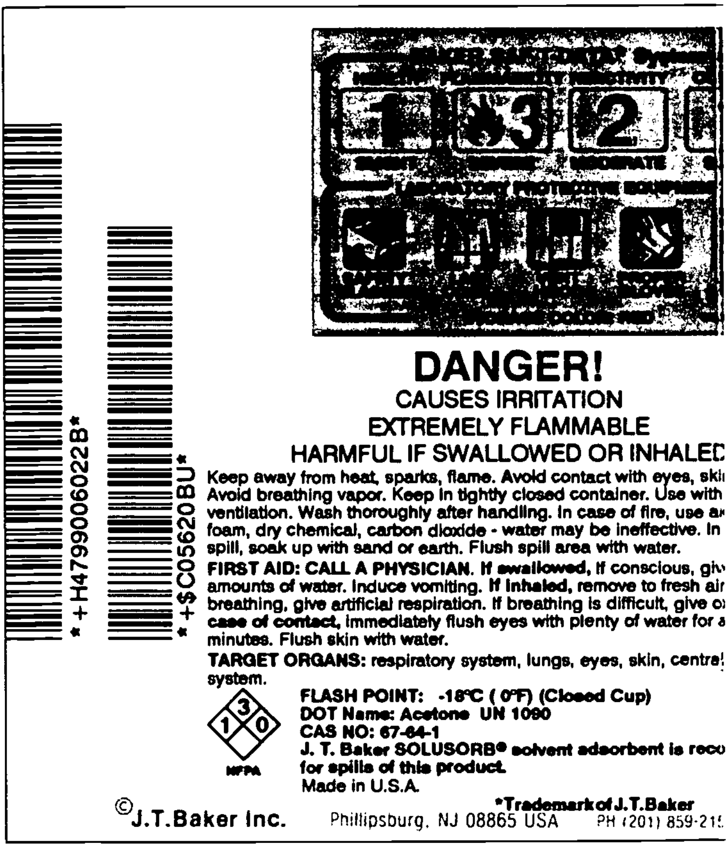


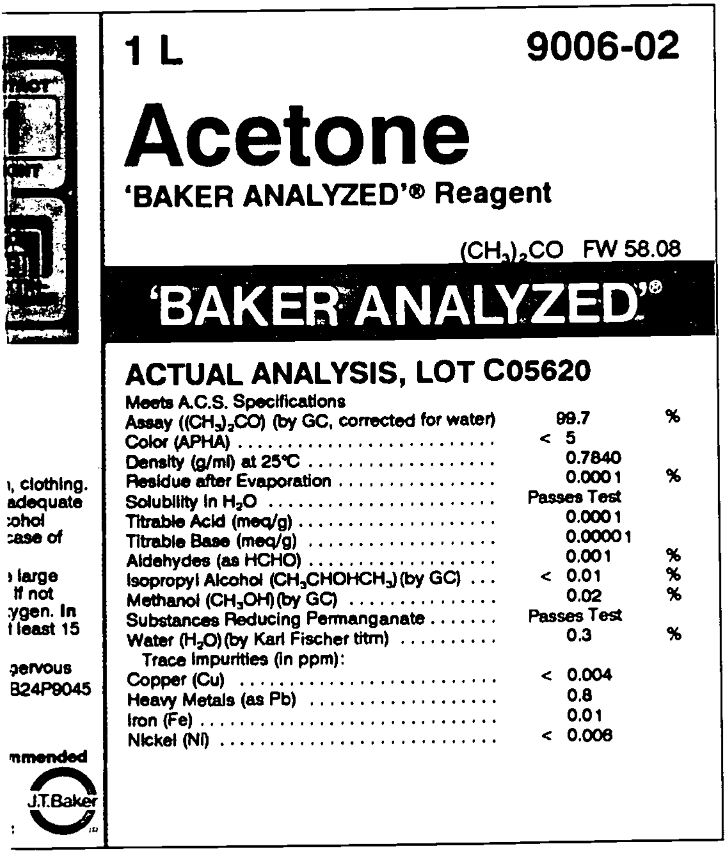
Figure 1. Example of a label.
(Courtesy of J.T. Baker).

BEST COPY AVAILABLE

If you are uncertain about the hazard potential of a product, consult the MSDS or ask the laboratory instructor.

Do not use a chemical unless you know what it is.

The wording on the label has been standardized by the American National Standards Institute to identify the precautions to be taken, hazards, organs that may be affected, storage requirements, and conditions to be avoided. Usually, information required for safe use of the product is also presented graphically via symbols and numbers.



1 L 9006-02

Acetone

'BAKER ANALYZED'® Reagent

$(CH_3)_2CO$ FW 58.08

'BAKER ANALYZED'®

ACTUAL ANALYSIS, LOT C05620

Meets A.C.S. Specifications

Assay ($(CH_3)_2CO$) (by GC, corrected for water)	99.7	%
Color (APHA)	< 5	
Density (g/ml) at 25°C	0.7840	
Residue after Evaporation	0.0001	%
Solubility in H_2O	Passes Test	
Titrable Acid (meq/g)	0.0001	
Titrable Base (meq/g)	0.00001	
Aldehydes (as HCHO)	0.001	%
Isopropyl Alcohol ($CH_3CHOHCH_3$) (by GC)	< 0.01	%
Methanol (CH_3OH) (by GC)	0.02	%
Substances Reducing Permanganate	Passes Test	
Water (H_2O) (by Karl Fischer titrn)	0.3	%
Trace Impurities (in ppm):		
Copper (Cu)	< 0.004	
Heavy Metals (as Pb)	0.8	
Iron (Fe)	0.01	
Nickel (Ni)	< 0.006	

One form of graphic labeling is the National Fire Protection Association (NFPA) 704 system (figure 2). The diamond-shaped label is divided into four colored quadrants: red for fire, yellow for reactivity, blue for health, and white for exceptional hazard (e.g., radioactive material, water-reactive material). Within each quadrant, there is a number, ranging from 0 to 4, with 0 indicating no threat and 4, the greatest potential threat for a firefighter in full equipment. In this system, the reactivity indicator refers to the reactivity of the substance in a fire, whereas a chemist is interested in the reactivity of the substance with living tissue and with chemicals.

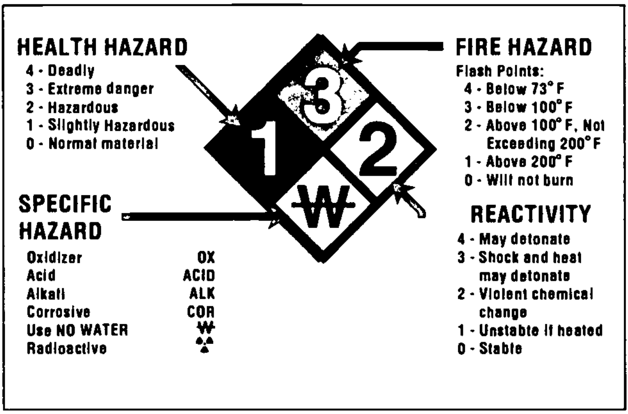


Figure 2. An NFPA label.

A recently developed system, similar to NFPA 704, identifies the potential chemical-related threat in four areas: red for fire, yellow for reactivity (with other chemicals), blue for health, and white for contact (i.e., how corrosive the substance is to living tissue). Under some circumstances, two other colors — green for inert gases, and orange for general chemicals — may also be used.

Color coding permits separation of incompatible chemicals for safe storage. Compatible products are labeled with the same color and can be grouped and stored together. Some companies supplement the color coding with stripes to discriminate even further in the storage of their products.

PERSONAL PROTECTIVE EQUIPMENT

Eye and face injuries are prevented by safety glasses with side shields for protection from dust and flying objects, chemical splash goggles for protection from spray and mist, and face and neck shields for protection from various hazards.

Laboratory coats or aprons protect against dirt, grease, some chemicals, radioactive materials, and microorganisms. The college/university must assign properly trained persons to handle contaminated garments.

Do not engage in activity that will result in heavy contamination of your clothing.

Exposure to strong acids, acid bases, organic chemicals, strong oxidizing agents, radioactive material, etiological agents, carcinogens, mutagens, and teratogens requires the use of special protective equipment prescribed in the MSDS.

Notes

HAZARDS

CHEMICAL HAZARD	EXAMPLES	EFFECT(S)
Carcinogen	Asbestos, benzidine, benzene, 2-naphthylamine, inorganic arsenic, 4-aminobiphenyl, methyl chloromethyl ether, bis-chloromethyl ether, vinyl chloride	Causes or promotes cancer
Sensitizer	Epoxies, anhydrides, toluene diisocyanate, nickel compounds, chromium compounds, chlorinated hydrocarbons	Allergic reaction ranging from dermatitis to anaphylactic shock (life-threatening loss of blood pressure)
Irritant	Ammonia, alkaline dust/mist, hydrogen chloride, hydrogen fluoride, halogens, ozone, phosgene, dimethyl sulfate, nitrogen dioxide, phosphorus chlorides, arsenic trichloride, isocyanates	Inflammation of skin and mucous membranes
	Sulfur dioxide, acetic acid, formaldehyde, formic acid, sulfuric acid, acrolein, iodine	Respiration and lung distress, chronic

sphyxiant	Simple gas asphyxiants: nitrogen, carbon dioxide, hydrogen, helium	Displaces oxygen in the tissue
	Chemical asphyxiants: carbon monoxide, cyanides	Renders the body incapable of utilizing oxygen
Primary anesthetic	Halogenated hydrocarbons, alcohols	Depressant effect upon the central nervous system
Hepatotoxic agent	Carbon tetrachloride, tetrachloroethane, nitrosamines, carbon disulfide	Liver damage
Nephrotoxic agent	Halogenated hydrocarbons, uranium compounds, cadmium and other heavy metals	Kidney damage
Neurotoxic agent	Trialkyltin compounds, tetraethyllead, methylmercury, carbon disulfide, manganese, thallium, n-hexane, acrylamide	Damage to the nervous system
Hematopoietic agent	Nitrites, aniline, toluidine, benzene, nitrobenzene	Adversely affects blood cells and bone marrow

HAZARDS

PHYSICAL HAZARD	EXAMPLES	CHARACTERISTICS
Explosive	Nitroglycerin, copper acetylide	Sudden, virtually instantaneous, release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature
Flammable substance	Liquid: acetone, toluene Solid: magnesium, sodium Gas: propane, acetylene	Flash point below 100°F (38°C)
Combustible liquid	Kerosene, ethylene glycol, monoethyl ether	Flash point at or above 100°F (38°C), but below 200°F (93°C)
Compressed gas	Nitrogen and hydrogen in cylinders (tanks)	Nonflammable gas: pressure greater than 40 psi (pounds per square inch) at 70°F 21°C) or greater than 104 psi at 130°F (54°C)

Organic peroxide	Dimethyl peroxide, benzoyl peroxide	Extremely unstable, especially in the dry state; explosive
Oxidizer	Hypochlorous acid, hydrogen peroxide	Initiates or abets combustion in other substances
Pyrophoric chemical	White phosphorus, silane	Ignites spontaneously at a temperature of 130°F (54°C) or less
Unstable chemical	Methyl methacrylate, isopropyl ether	Vigorously polymerizes, decomposes, condenses, or becomes self-reactive when subjected to shock, pressure, or increased temperature
Water-reactive chemical	Sodium, calcium carbide	Reacts with water to release a gas that is either flammable or hazardous to health

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TOXICITY

Toxicity of a chemical refers to its potential to injure when it comes into contact with, or gains entry into, the body. For example, benzene, which may be absorbed through the skin or inhaled, is toxic in that it can damage the blood-forming elements in the bone marrow.

Some toxic chemicals affect a single function within the body, whereas other toxic chemicals affect multiple functions. Moreover, you may be more sensitive than other people to a particular chemical and experience problems at lower exposure levels.

Avoid exposure not only to known toxic chemicals, but also to possibly toxic chemicals, through careful laboratory work practices.

Acute Toxicity

Acute toxicity can be characterized by rapid absorption of a chemical during a single exposure. The effect can be sudden, possibly severe, and sometimes fatal—for example, serious chemical burns or disabling damage to the eyes, lungs, or nervous system.

Some chemicals, such as gaseous arsines and cyanides, are extremely toxic; exposure to even small amounts of these gases can cause death.

Some toxic chemicals, such as formaldehyde and mercaptans, emit a distinctive odor, but others, such as carbon monoxide, are odorless.

Never depend on your ability to smell chemicals as a safeguard against potential hazards.

Chronic Toxicity

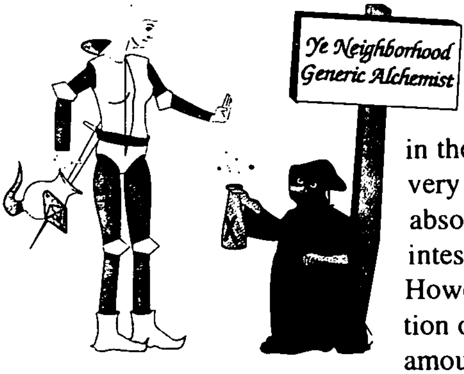
Chronic toxicity is characterized by prolonged, or repeated, less-than-acute exposure over a period of days, months, or even years. Chronic toxicity often results in cumulative effects on many organs or parts of the body. Some effects can be reversed if the exposure is eliminated; other effects are irreversible.

Depending on the acute or chronic toxic nature of the exposure, the same chemical often has decidedly different effects. For example, acute exposure to a chlorinated hydrocarbon, such as chloroform or methylene chloride, causes nervous system intoxication in the form of headache or dizziness. Chronic exposure, however, causes irreversible brain damage and/or hepatic carcinoma (liver cancer).

An acutely toxic chemical may have little or no effect under conditions of chronic exposure. Conversely, a chronically toxic chemical may have little or no effect under conditions of acute exposure.

A large quantity of vitamin D, sodium fluoride, or table salt ingested at one time can be acutely toxic, however, small quantities are not only nontoxic, but may enhance your well-being.

On the other hand, a single ingestion of a large amount of metallic mercury is not likely to cause death, or even illness, for most of it will pass in the feces, and very little will be absorbed by the intestinal tract. However, ingestion of a small amount on a daily basis can ultimately have the cumulative effect of causing chronic mercury poisoning.



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EFFECTS OF EXPOSURE TO TOXIC CHEMICALS

Local Effect

Local effect occurs at the point, or area, of contact, such as the skin, mucous membranes, eyes, respiratory tract, or gastrointestinal system.

Systemic Effect

Systemic effect occurs at a site away from the point of contact. For example, dimethyl sulfoxide absorbed through the skin affects the liver.

Synergistic Effect

Synergistic effect (also called potentiating effect) may occur in some cases, when two or more hazardous chemicals are present at the same time. A synergistic effect is more severe than the effect of each separate chemical.

ROUTES OF EXPOSURE

You are seldom exposed to a chemical through only one route. If an MSDS or a label identifies only a single route of exposure, it is usually the primary route.

Skin and Eye Contact

The skin normally is an effective protective barrier, but certain chemicals can penetrate the skin. As a general rule, inorganic chemicals, with the exception of hydrofluoric acid, are absorbed poorly through the skin, whereas the absorption of organic chemicals varies according to conditions.

Toxicity depends on the amount of chemical absorbed, as determined by the concentration of the chemical, the physical form of the chemical, and the length of time the chemical is in contact with the skin. A chemical in dry powder form is usually not absorbed as readily as when it is in an aqueous solution. In addition, certain solvents, such as dimethyl sulfoxide, xylene, and benzene, greatly enhance absorption of many chemicals.

Skin contact frequently causes localized irritation, whereas recurring contact can cause dermatitis.

Wear a laboratory coat or apron, and protective gloves, to reduce the threat of contact with the skin.

Remove clothing immediately after any contamination, in order to minimize the amount, and length of time, of chemical contact with the skin.

Each laboratory should have disposable lab coats.

Do not launder contaminated clothing with other clothing.

Eye exposure is a matter of particular concern. Alkaline materials, phenols, and strong acids are particularly corrosive to the eyes and can cause permanent loss of vision.

Always wear safety goggles when handling chemicals.

INHALATION

Chemical vapors, mists, gases, or dusts absorbed through the mucous membranes of the mouth, nose, throat, and lungs can damage the tissue at those sites and pass rapidly, via the lungs, into the bloodstream.

Airborne chemicals take three forms: aerosol, gas, and vapor.

- An aerosol is a dispersion of small liquid or solid particles (e.g., smoke, spray, mists, dusts), often generated by stirring, blending, centrifuging, or pouring chemicals. Generally, particles smaller than 10 micrometers in diameter represent the greatest hazard in that they can become deposited in the deep reaches of the lungs, where removal is difficult, if not impossible. Larger particles are usually removed by cilia, the tiny fibers that line your respiratory system, and returned to your mouth. From the mouth, most of the particles pass into your gastrointestinal system and are safely eliminated from your body. On rare occasions, these particles may constitute an ingestion hazard.

- A gas is a chemical that is in a gaseous state at normal room temperature and pressure. Carbon monoxide, hydrogen sulfide, and nitrogen dioxide are examples of gases.
- A vapor is the gaseous form of a chemical, such as benzene or naphthalene, that is liquid or solid at normal room temperature and pressure.

Inhalation hazards arise when a chemical becomes airborne as a result of evaporation. A chemical with a high vapor pressure (e.g., ethyl ether, benzene, xylene) tends to evaporate more readily than a chemical with a low vapor pressure (e.g., mineral oil). However, if the exposed surface area is large enough and the temperature is sufficiently high, chemicals with very low vapor pressures can reach toxic inhalation levels.

The solubility of a chemical in water is important in evaluating inhalation exposure. Particles enter the lungs during inhalation. Water-soluble particles dissolve upon contact with lung tissue, then diffuse through the lung tissue, and enter the circulatory system.

INGESTION

Do not eat, drink, or store food in the laboratory.

Exposure through ingestion occurs much less frequently than exposure through contact or inhalation. A likely scenario would be one in which someone still wearing latex gloves from working with a toxic chemical opens a door, or answers a telephone, and someone else touches the item thus contaminated, then eats a piece of candy or chews a stick of gum.

INJECTION

The rare instances of injection of toxic chemicals have largely resulted from mishandling a syringe or from penetration of the skin by contaminated broken glass.

Notes

DOSE

A key consideration in determining the hazard associated with a chemical is the amount of the chemical actually taken into the body (the dose) in relation to the toxicity of the chemical. The actual dose is not readily determined, so the dose is estimated on the basis of the concentration of the chemical in the breathing zone of the person and/or the amount in contact with the skin.

For each toxic chemical, there is a threshold dose (often referred to merely as the threshold): the dose that produces no measurable toxic effect.

EXPOSURE LIMITS

There are two exposure limits referenced in an MSDS: the permissible exposure limit (PEL) and the threshold limit value (TLV).

The PEL is a legal standard established by OSHA. The TLV is a recommended airborne occupational exposure standard developed by the American Conference of Government Industrial Hygienists.

The TLV is the average concentration of a chemical that a healthy worker can be exposed to over a working lifetime with no ill effects. TLVs for vapor or gas are expressed as parts per million parts (ppm) by volume; TLVs for aerosols, as milligrams of particulate per cubic meter (mg/m^3). When applicable, a ceiling concentration — a maximum concentration that should never be exceeded — and a skin absorption hazard will be listed with the TLV.

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The TLV and the PEL are derived from time-weighted averages, the average exposure weighted time for an 8-hour workday. Ceiling limits, short-term exposure limits, and action levels (one-half the PEL must be considered when exposures are evaluated. The MSDS will list the TLV and PEL for the hazardous chemical or for each component of a hazardous mixture.

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Consult your college or university library for additional information.

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Notes

HOTLINES

American Chemical Society Health & Safety Referral Service	800/227-5558 Option 6
Chemical Abstract Service	800/848-6538
Chemical Manufacturers Assoc.	800/262-8200
Chemical Transportation Emergency Center	800/424-9300
Federal OSHA (Tech Support)	202/219-7031
National Institute for Occupational Safety and Health Technical Information	800/35-NIOSH
National Library of Medicine	301/496-4000
Poison Control Center *(Please consult your local telephone listing or directory assistance for the local/regional poison control center.)*	
U.S. Consumer Product Safety Commission	800/638-2772
U.S. Department of Labor Bulletin Board System *(Need modem to dial in)*	202/219-4784
U.S. EPA Chemical Emergency Preparedness Program Emergency Planning and Community Right-to-Know Information	800/535-0202
U.S. EPA Resource Conservation and Recovery Act/Superfund Hotline	800/424-9346
U.S. EPA Small Business Ombudsman Hotline Compliance with any EPA regulation	800/368-5888
U.S. EPA Toxic Substances Control Act Hotline	202/554-1404

CHEMICAL HYGIENE PLAN SIGN-OFF FORM*

(To be Returned to the Institution)

Course: ______________________________ Instructor: ______________________________

____

Name: ______________________________ Student ID: ______________________________

I have read and understand the Chemical Hygiene Plan, the institution's plan for working with chemicals, as it applies to laboratory experiments. I have met with my instructor and have had an opportunity to have the MSDS explained to me and have my questions answered. I agree to implement all safety procedures and precautions for handling chemicals. If I have any additional questions regarding this plan or the chemicals that I may be required to use, I will discuss them with my instructor before initiating any activity with these materials.

______________________________________ ______________________________

Student's signature Date

I have discussed the institution's Chemical Hygiene Plan with this student and answered any questions he or she had regarding it.

______________________________________ ______________________________

Instructor's signature Date

The American Chemical Society intends this form to be a recommendation. It is not a legal standard which institutions must follow.

STUDENT HAZARDOUS CHEMICALS USAGE SHEET*

(Listing of Chemicals for Use in the Laboratory Course)

Laboratory ______________________________

Instructor ______________________________

Enter a check mark if a designated area (DA) is required.

DATE	HAZARDOUS CHEMICAL NAME	CAS#	QTY	SOURCE	OWNER	DA

*The American Chemical Society intends this form to be a recommendation. It is not a legal standard which institutions must follow.

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Notes

A GUIDE FOR STUDENTS

PRUDENT LABORATORY PRACTICES

The following list contains DOs and DON'Ts for safe laboratory practices.

- ✓ Do not work alone in the laboratory.
- ✓ Use required personal protective equipment.
- ✓ Label all containers with appropriate hazard information.
- ✓ Wash hands thoroughly with soap and water after handling any laboratory chemical.
- ✓ Avoid direct contact with any chemical.
- ✓ Keep laboratory chemicals off hands, face, and clothing (including shoes).
- ✓ Never smell, inhale, or taste laboratory chemicals.
- ✓ Do not smoke, drink, eat, or apply cosmetics in areas where laboratory chemicals are in use.
- ✓ Always use chemicals with adequate ventilation or in a chemical fume hood.
- ✓ Use chemicals only as directed and for their intended purpose.
- ✓ Inspect equipment or apparatus for damage before adding a laboratory chemical. Do not use damaged equipment.
- ✓ Never use mouth suction to fill a pipet. Use a pipet bulb or another pipet-filling device.
- ✓ Use approved methods, electrically-ground and bond containers, when transferring or dispensing a flammable liquid.
- ✓ For specific information regarding chemical handling, contact the laboratory supervisor.

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